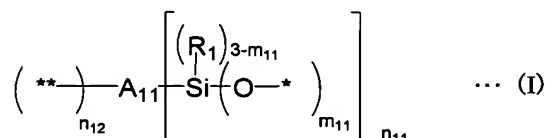


CLAIMS

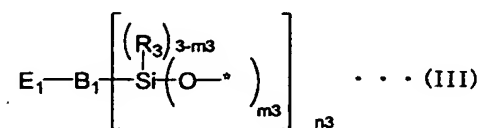
1. A proton-exchange membrane having a structure of mesogen-containing organic molecular chains and a proton-donating group-containing group covalent-bonding to a silicon-oxygen three-dimensional crosslinked matrix, in which at least a part of the organic molecular chains are oriented to form an aggregate thereof.

2. The proton-exchange membrane of claim 1, which contains a partial structure of the following formula (I):



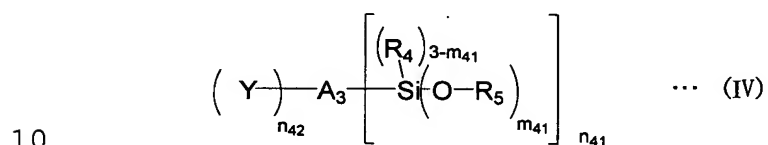
wherein A_{11} represents a mesogen-containing organic atomic group; R_1 represents an alkyl group, an aryl group or a heterocyclic group; m_{11} indicates an integer of from 1 to 3; n_{11} indicates an integer of from 1 to 8; n_{12} indicates an integer of from 0 to 4; $*$ indicates the position at which the structure bonds to a silicon atom; and $**$ indicates the position at which the structure bonds to an organic polymer chain.

3. The proton-exchange membrane of claim 1, wherein the proton-donating group covalent-bonds to the silicon-oxygen three-dimensional crosslinked matrix via a structure of the following formula (III):



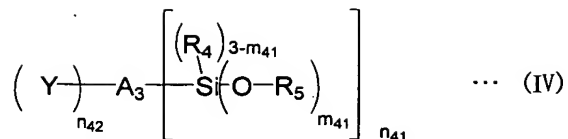
wherein B₁ represents a linking group that contains an aliphatic group and/or an aromatic group; R₃ represents an alkyl group or an aryl group; E₁ represents a proton-donating group; m₃ indicates an integer of from 1 to 3; n₃ indicates an integer of from 1 to 4; and * indicates the position at which the structure bonds to a silicon atom.

4. The proton-exchange membrane of claim 1, which is obtained through sol-gel reaction of a precursor, organosilicon compound of the following formula (IV):

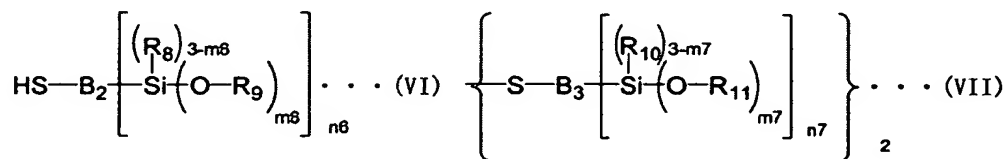


wherein A₃ represents a mesogen-containing organic atomic group; R₄ represents an alkyl group, an aryl group or a heterocyclic group; R₅ represents a hydrogen atom, an alkyl group, an aryl group or a silyl group; Y represents a polymerizing group capable of forming a carbon-carbon bond or a carbon-oxygen bond through polymerization; m₄₁ indicates an integer of from 1 to 3; n₄₁ indicates an integer of from 1 to 8; n₄₂ indicates an integer of from 0 to 4; when m₄₁ is 2 or more, R₅'s may be the same or different.

5. The proton-exchange membrane of claim 1, in which is used a sulfonic acid sol obtained through oxidization of a solution that contains an organosilicon compound of the following formula (IV), and an organosilicon compound of the following formula (VI) and/or (VII):

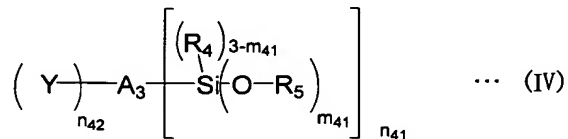


wherein A_3 represents a mesogen-containing organic atomic group;
 R_4 represents an alkyl group, an aryl group or a heterocyclic
group; R_5 represents a hydrogen atom, an alkyl group, an aryl
5 group or a silyl group; Y represents a polymerizing group capable
of forming a carbon-carbon bond or a carbon-oxygen bond through
polymerization; m_{41} indicates an integer of from 1 to 3; n_{41}
indicates an integer of from 1 to 8; n_{42} indicates an integer
of from 0 to 4; when m_{41} is 2 or more, R_5 's may be the same or
10 different,

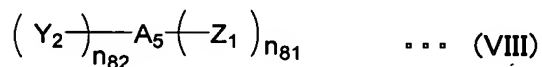


wherein B_2 and B_3 each represent a linking group that contains
an aliphatic group and/or an aromatic group; R_8 and R_{10} each
represent an alkyl group or an aryl group; m_6 and m_7 each indicate
15 an integer of from 1 to 3; n_6 and n_7 each indicate an integer
of from 1 to 4; R_9 and R_{11} each represent a hydrogen atom, an
alkyl group, an aryl group or a silyl group; when m_6 or m_7 is
2 or more, R_9 's or R_{11} 's may be the same or different.

6. The proton-exchange membrane of claim 1, which is
20 obtained through sol-gel reaction of a compound of the following
formula (IV) with from 1 mol% to 50 mol% of a compound of the
following formula (VIII):

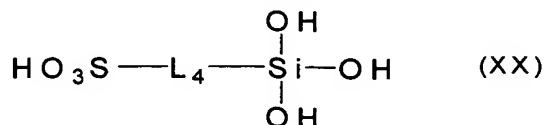


wherein A_3 represents a mesogen-containing organic atomic group;
 R_4 represents an alkyl group, an aryl group or a heterocyclic
group; R_5 represents a hydrogen atom, an alkyl group, an aryl
5 group or a silyl group; Y represents a polymerizing group capable
of forming a carbon-carbon bond or a carbon-oxygen bond through
polymerization; m_{41} indicates an integer of from 1 to 3; n_{41}
indicates an integer of from 1 to 8; n_{42} indicates an integer
of from 0 to 4; when m_{41} is 2 or more, R_5 's may be the same or
10 different,



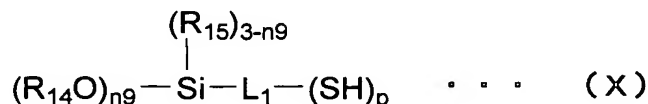
wherein A_5 represents a mesogen-containing organic atomic group;
 Z_1 represents a substituent not changing in sol-gel reaction,
or a hydrogen atom; n_{81} indicates an integer of from 1 to 8;
15 n_{82} indicates an integer of from 0 to 4; Y_2 represents a polymerizing
group capable of forming a carbon-carbon bond or a carbon-oxygen
bond through polymerization; when n_{81} is 2 or more, Z_1 's may be
the same or different.

7. The proton-exchange membrane of claim 1, in which
20 is used a sol obtained through hydrolysis and polycondensation
of a precursor of the following formula (XX) in the presence
of water and an oxidizing agent:

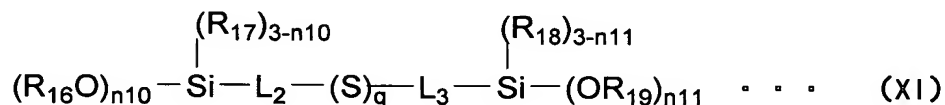


wherein L₄ represents a divalent linking group.

8. The proton-exchange membrane of claim 1, in which is used a sol obtained through hydrolysis and polycondensation of a precursor of the following formula (X) and/or (XI) in the presence of water and an oxidizing agent:



wherein L₁ represents a (p+1)-valent linking group; R₁₄ and R₁₅ each represent an alkyl group or an aryl group; n₉ indicates 2 or 3; at least one R₁₄ is an alkyl or aryl group having at least 3 carbon atoms; R₁₄'s may be the same or different; and p indicates an integer of from 1 to 3,



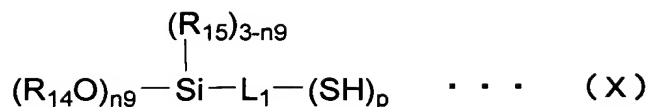
wherein L₂ and L₃ each represent a divalent linking group, R₁₆ to R₁₉ each represent an alkyl group or an aryl group; n₁₀ and n₁₁ each indicate 2 or 3; at least one R₁₆ and at least one R₁₉ each are an alkyl or aryl group having at least 3 carbon atoms; R₁₆'s and R₁₉'s each may be the same or different; and q indicates an integer of from 2 to 4.

9. A membrane electrode assembly comprising the proton-exchange membrane of claim 1.

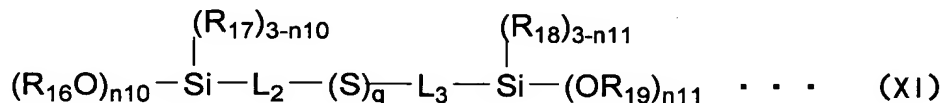
10. A fuel cell comprising the proton-exchange membrane of claim 1.

11. A silica sol composition obtained through hydrolysis and polycondensation of at least one precursor of the following formulae (X) and (XI) in the presence of water and an oxidizing

agent:



wherein L_1 represents a $(p+1)$ -valent linking group; R_{14} and R_{15} each represent an alkyl group or an aryl group; $n9$ indicates
 5 2 or 3; at least one R_{14} is an alkyl or aryl group having at least 3 carbon atoms; R_{14} 's may be the same or different; and p indicates an integer of from 1 to 3,



wherein L_2 and L_3 each represent a divalent linking group, R_{16}
 10 to R_{19} each represent an alkyl group or an aryl group; $n10$ and $n11$ each indicate 2 or 3; at least one R_{16} and at least one R_{19} each are an alkyl or aryl group having at least 3 carbon atoms; and q indicates an integer of from 2 to 4.